SNAKE PLAIN AQUIFER

TECHNICAL REPORT

September 1985

IDAHO DEPARTMENT OF HEALTH AND WELFARE
IDAHO DEPARTMENT OF WATER RESOURCES

SNAKE PLAIN AQUIFER

TECHNICAL REPORT

September 1985

IDAHO DEPARTMENT OF HEALTH AND WELFARE
IDAHO DEPARTMENT OF WATER RESOURCES

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES

DISCLAIMER

Preparation of this document was financed in part by the Environmental Protection Agency. The opinions, findings, and conclusions expressed in this document are those of the authors and not necessarily those of the Environmental Protection Agency.

INTRODUCTION

Background

The Safe Drinking Water Act (Public Law 93-523) allows the designation of an aquifer as a sole or principal source of drinking water if it is determined that, by contamination; it would create a significant public health hazard. In September 1982 The Hagerman Valley Citizens Alert, Inc. petitioned the U.S. Environmental Protection Agency (EPA) to designate the groundwater beneath the Snake Plain of Southeastern Idaho as a sole source aquifer. Subsequently a notice was made in the Federal Register on February 9, 1983. The notice announced receipt of the petition and requested public comment.

Designation of the aquifer as a sole source of drinking water would give EPA review authority to help insure certain Federally-funded or guaranteed projects that may have public health impacts on such aquifer are planned and designed "to assure that they will not so contaminate the aquifer". The Federal agencies affected by such designation are those which may provide a grant, contract, loan guarantee or other form of financial assistance. Those agencies are the Federal Highway Administration, Bureau of Reclamation, Economic Development Administration, Farmers Home Administration, Department of Housing and Urban Development, Soil Conservation Service, Veterans Administration, Federal Aviation Administration and the Small Business Administration. No other extraordinary control of contamination to the aquifer would be otherwise assured by such designation.

In cooperation with the EPA, the U.S. Geological Survey (USGS) prepared a summary report of Hydrologic, Demographic, and Land-Use Data for the Snake River Plain, Southeastern Idaho (Young and Jones, 1984). The purpose of the report was to provide information on the availability, condition, and uses of the groundwater in the Snake Plain. It was based on the available data from previous studies and was used by EPA in the sole source aquifer decision-making process. The boundaries of the aquifer are shown on Plate 1.

EPA's Region X office in Seattle, Washington, subsequently published a Support Document For the Designation of the Snake River Plain Aquifer as a Sole Source Aquifer (Marshall, 1984). It was the regional office's conclusion that the Snake Plain Aquifer is the principal source of drinking water for the eastern Snake Plain Basin. The office also determined that

SNAKE PLAIN AQUIFER AND DRAINAGE BASIN

PLATE 1

SOURCE: "WATER RESOURCES INVESTIGATIONS" USGS PUBL. 84-4001 the aquifer was susceptible to contamination and that such contamination, due to the limitations on alternative sources of drinking water, could result in a significant public health hazard. The office, therefore, recommended the designation of the aquifer as a sole source.

On August 20, 1984, Governor John Evans requested that EPA delay the designation of sole source for the aquifer, stating his belief that the State could best manage the aquifer. He cited the following in requesting the delay in sole source designation:1) the technical information and knowledge developed at the present time are insufficient to support the proposed administrative action, 2) the classification of the sole source designation would fail to recognize the need for a more balanced regulatory approach, coordinating both water quality and quantity issues, and 3) such designation would significantly inhibit the resolution of the Swan Falls water rights issue. In November, 1984, after meeting with Governor Evans and state officials, Ernesta Barnes, Regional Administrator for EPA, confirmed that the agency would forego such designation at that time. It was the EPA's belief that the state groundwater management program could go beyond the scope of protection that would be provided by sole source designation.

In February 1985, the EPA released additional funds under Section 106 of the Clean Water Act (Public Law 92-500). These funds were designated for use by states to "help develop a comprehensive groundwater protection plan". Although the funds could be used for both development and implementation of groundwater protection strategies, the Fiscal Year 1985 funds were to be used in the development of state groundwater protection action plans or strategies. Using a part of those funds and in cooperation with the Idaho Department of Water Resources, the Idaho Department of Health and Welfare's Division of Environment (IDHW-DOE) developed a work plan to formulate a management strategy for the Snake Plain Aquifer. The plan, accepted by the EPA on March 5, 1985, was to be completed by October 1, 1985. It includes the following elements:

1. Identify the unique characteristics of the aquifer.
2. Compile a summary of the existing water quality data.
3. Compile a summary of the potential groundwater quality problems.
4. Identify potential control mechanisms such as regulation development and State management to protect the aquifer water quality.
5. Develop a basic management strategy.
6. Identify potential problems in management or administration of the developed plan.

Report Purpose

This report provides the technical data gathered from the first three elements of the work plan, that is, the characterization of the aquifer and plain, summarization of existing water quality water data and identification of potential groundwater contamination problems. Such information has been summarized to assist in the development of a strategy to manage the water quality of the Snake Plain Aquifer.

Agency Involvement

The report has been prepared in cooperation with the following State and Federal agencies:

Idaho Department of Health and Welfare
Idaho Department of Water Resources
Idaho Department of Lands
Idaho Department of Agriculture
U.S. Geological Survey
U.S. Bureau of Land Management
U.S. Soil Conservation Service.

SNAKE PLAIN AND AQUIFER CHARACTERISTICS

HYDROLOGY

Hydrogeological Setting

The Snake Plain Aquifer is characterized by a succession of Quaternary basaltic lava flows, often separated by alluvial, volcaniclastic, or eolian interbeds. The total thickness of the sequence is largely unknown, but may locally exceed several thousand feet. A test well (INEL-1) drilled at the Idaho National Engineering Laboratory (INEL) in 1979 to a depth to 10,365 feet penetrated about 2500 feet of basaltic lava and sedimentary and volcaniclastic interbeds. The basalt flows themselves often have cindery, clinkery zones at their tops, which are capable of transmitting water freely. Interbeds of alluvial material, such as sand and gravel, also transmit water, but generally less freely than the cinder zones. Interbeds of fine-grained material, such as clays or windblown silt, often fill the voids which are present at the flow tops, greatly reducing the amount of water which can be transmitted. In fact, these zones typically prevent the downward percolation of water applied at the land surface, often creating perched water zones separate from the regional groundwater system. Older, less permeable rhyolitic rocks underlie the basalts and probably form the base of the Snake Plain Aquifer. In INEL-1, rhyolitic rocks extended from 2500 feet to the total of 10,365 feet.

The thickness of individual basalt flows generally ranges from 10 to 50 feet, and averages 20 to 25 feet (Mundorff et al., 1964). A well drilled to a depth of 200 to 300 feet below the water table will therefore encounter several water-bearing zones between the flows, each with often different water-bearing capabilities. Interbedded sediments, depending on their thickness, frequency of occurrence, and permeability can have a profound impact upon recharge to and discharge from the aquifer, can alter flow patterns and act upon introduced contaminants in a manner quite different from the basalts. Since their hydrologic characteristics vary considerably both laterally and vertically, sedimentary interbeds add greatly to the complexity of the hydrogeology of specific areas.

A case in point is the so-called "Mud Lake barrier", a generally northwest-trending linear feature in the subsurface south and east of Mud Lake. This "barrier" is a zone of significant interfingering of highly permeable basalts with sedimentary lake beds of low permeability. The lake beds act as a dam of barrier to water moving generally southwestward, locally causing very steep groundwater gradients within the barrier area. At least two other "barriers", generally transverse to the axis of the plain, are known to exist, dividing the aquifer into several compartments. The nature of these barriers and their effect on groundwater flow should be the subjects of future study.

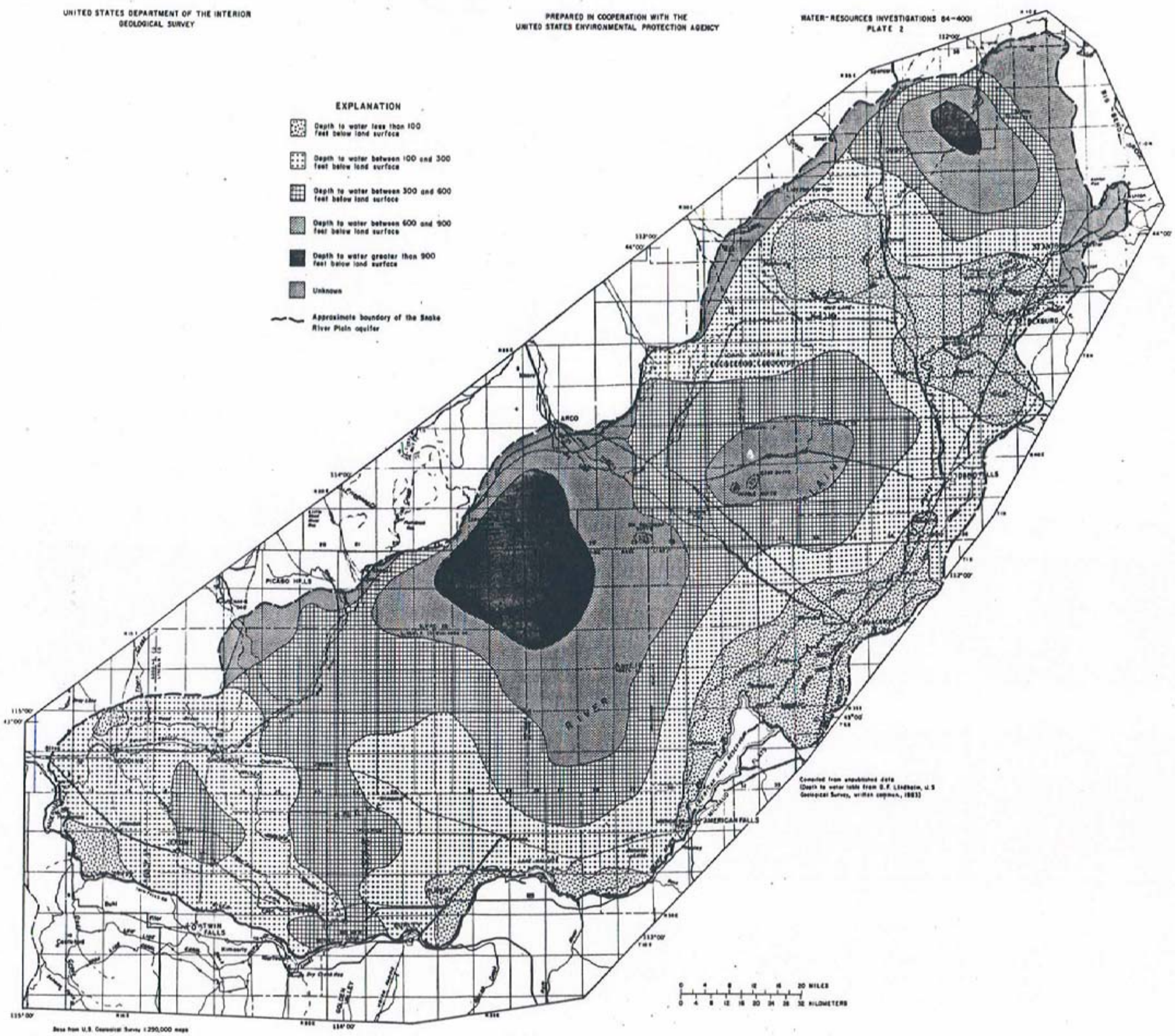
Interflow zones between successive basalt flows consist of pyroclastic and sedimentary materials. Where highly permeable they are the major avenues for horizontal movement of water within the aquifer. Where they consist of clay or other impermeable materials, they may act as confining layers, preventing the downward movement of water, creating a perched aquifer; or they may act as a "lid" on an underlying aquifer, confining it under pressure. The transmissivity of the aquifer (the rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient) is generally high. Reported values of transmissivity range from 500,000 ft^2/day to as high as 13,000,000 ft^2/day (Lindholm, 1981), putting them among the highest known in the nation.

Depth to Water

Depth to water in the Snake Plain Aquifer ranges from less than 100 feet to more than 900 feet below land surface (Plate 2). As shown by Plate 2, depth to water is greatest in the central and northern parts of the aquifer. In areas near the western, southern and eastern margins of the aquifer, depth to water is generally less than 300 feet and is coincident in area with most of the development and water use. However, since perched aquifers often develop beneath irrigated tracts and are poorly defined, water levels in wells completed in these perched aquifers will often give very misleading values for depth to water. The basic depth and construction of the well must be known before one can be sure than depth to water is that of the regional groundwater system and not that of a localized, perched aquifer.

Groundwater Movement

The general direction of groundwater movement can be inferred from contours on the water surface (Plate 3). Movement is down the hydraulic gradient and roughly perpendicular to the water-level contours, from areas of recharge to areas of discharge. The position of the water surface in March 1980 is shown on Plate 3. Arrows on the plate show the general direction of groundwater movement.

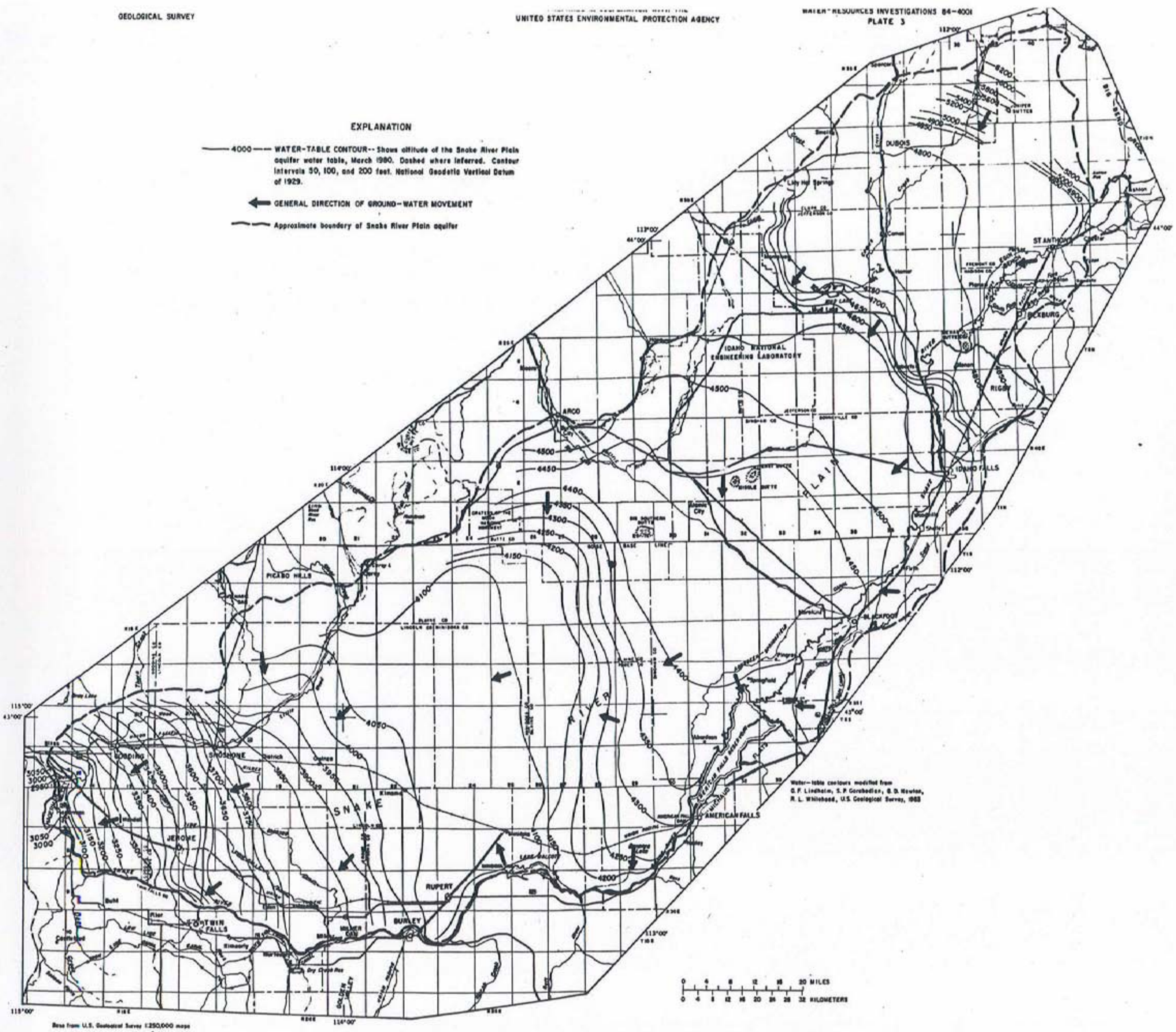


DEPTH TO WATER, MARCH 1980, IN THE SNAKE RIVER PLAIN AQUIFER

GEOLOGICAL SURVEY

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

WATER-RESOURCES INVESTIGATIONS 84-4001
PLATE 3



WATER-TABLE CONTOURS, MARCH 1980, IN THE SNAKE RIVER PLAIN AQUIFER

The direction of groundwater movement can be significantly modified on a local basis by application of surface water, by drawdown due to heavy pumpage, local geologic conditions, and seasonal variations in recharge and discharge. Use of Plate 3, therefore, should be restricted to generally large areas. Site-specific studies and water table maps are more appropriate, and often required, before meaningful conclusions can be made regarding the fate of contaminants reaching the local groundwater system.

Water is often moves more easily laterally than vertically. Where the interbedded material consists of alluvial, eolian and pyroclastic material, its vertical and horizontal permeability depends upon such factors as sorting and stratification, compaction, and degree of cementation. All these factors can be highly variable, and can create an extremely complex structure within which groundwater moves. Water is frequently found to be stratified in water-bearing zones quite separate from one another. As Mundorff et al. (1964) put it:

> "The inability of water to move freely between superimposed water-bearing zones is demonstrated by the commonly observed, slight but significant, differences in water levels in successive zones."

This factor is important in its implications for groundwater contamination, and in the development of three-dimensional flow and solute-transport numerical models. Where the confining layers between successive water-bearing zones consist of massive, dense basalt, little vertical leakage of water, with or without dissolved contaminants, can take place. Where confining beds consist of silt to clay, however, appreciable vertical leakage can take place, especially when the areal extent of the confining layer is considered. Information on the areal distribution and hydrologic characteristics of these confining layers is virtually non-existent; without data concerning these layers, few conclusions can be drawn. In areas of recharge on the Plain, heads decrease with depth, causing downward movement of water. Some of the Plain is characterized by either little or no change in head with depth, or the head generally increase, tending to cause upward movement of water. Only in very few locations is the distribution of head with depth known, and then not through the entire saturated thickness of the aquifer. Upward or downward velocities of water under such conditions are essentially unknown but are probably low.

Calculated values of horizontal groundwater velocities in the aquifer are high. Assuming a saturated thickness of 1,000 feet, an average water-table gradient of 5 feet per mile, a porosity of 0.5, and transmissivity values of 500,000 to 13,000,000 ft^2/day, calculated groundwater velocities range from .95 feet per day to 24.6 feet per day. It should be stressed that the calculated velocities are <u>average</u> velocities and are based on data from well tests under very localized conditions. According to Lohman (1972) the calculated velocity "...does not necessarily equal the actual velocity between any two points of the aquifer, which may range from less than, to more than this value, depending upon the flow path followed. Thus (the equation used to calculate average velocity) should not be used for predicting the velocity and distance of movement of, say, a contaminant in the groundwater."

This aspect of determining groundwater velocity is especially important to remember when considering contaminant movement in fractured media, such as basalt, due to the highly irregular fracture occurrence and orientation involved. Most mathematical analyses of dispersion of a contaminant assume the aquifer to be homogenous and isotropic, however, this assumption fails in fractured rock aquifers, especially on a local scale. It is simply not possible to know the fracture orientation, bulk fracture porosity, degree of vertical and horizontal connection of fractures and other parameters in sufficient detail to be able to predict with confidence the dispersion of a contaminant under these conditions. This is particularly true when the contaminant may have percolated down through a thick unsaturated zone before reaching the aquifer.

<u>Water-Level Fluctuations</u>

Groundwater levels fall in response to discharge from the aquifer and rise in response to recharge. Fluctuations are important on both short-term (minutes, days, months) and long-term (years) bases. Hydrographs of water-level fluctuations can reveal stresses on the aquifer and whether water in storage is increasing or decreasing over the long term.

The character of fluctuations in agricultural areas depends on whether groundwater or surface water is the principal source of water for irrigation. Where surface water is the source, groundwater levels start to rise after the beginning of an irrigation season as some of the applied water percolates to the saturated zone. A decline in water levels generally is observed shortly after the end of the season.

An area with mixed surface water/groundwater use may have a more complex pattern of water-level changes. Interpretation of the water-level hydrographs requires more knowledge of relative quantities and timing of application of surface and ground waters. However, the pattern of the dominant use in a particular area usually prevails. Many areas undergoing a shift from surface water to groundwater use may show a significant change in patterns over time.

Water levels in areas not influenced by irrigation are either relatively stable or start to rise in early spring in response to snowmelt. Water levels peak in late spring or early summer, then gradually decline The decline continues through fall and winter until spring snowmelt again recharges the aquifer.

Hydrographs of water levels in 10 selected wells are shown on Plate 4. Water level fluctuations in the Snake Plain Aquifer generally reflect the source of irrigation water. Well 4S-33E-3DBB2 shows fluctuations typical of an area of surface water irrigation where canal losses and seepage from fields constitute the principal source of recharge. Well 8S-24E-31DAC1 shows fluctuations typical of an area of groundwater irrigation where water levels start to decline at the start of the pumping season.

In addition to repetition of seasonal fluctuations, hydrographs on Plate 4 show long-term (several years) trends. Generally, water levels in both surface and ground water irrigated areas show declines starting in the mid-1970's. These downward trends are probably the result of increasing groundwater withdrawals, reduced recharge from surface water owing to changes in irrigation practices, and two periods or reduced precipitation; or a combination of these factors.

<u>Recharge to and Discharge from the Aquifer</u>

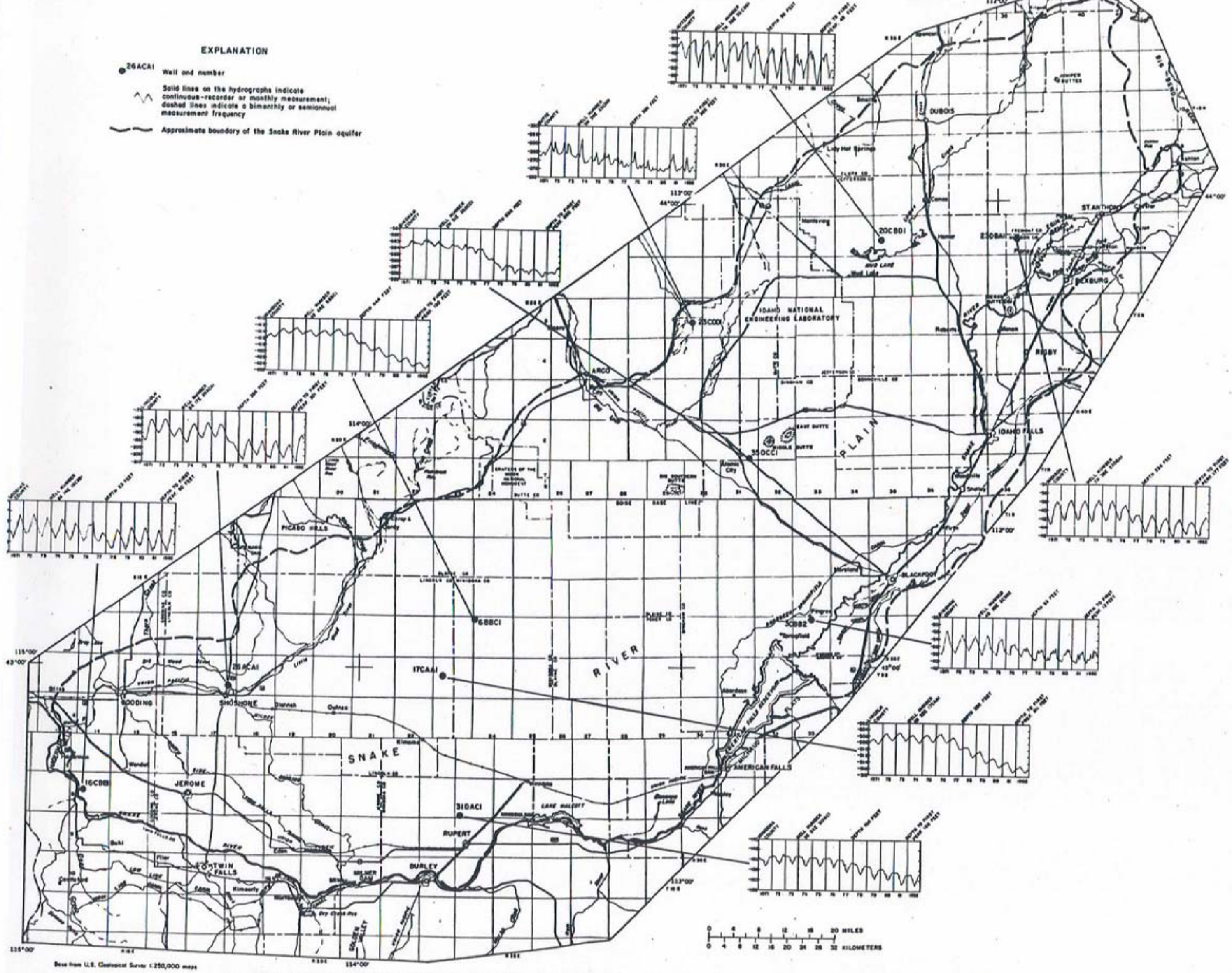
Plate 5 shows locations and estimates of recharge to and discharge from the aquifer and contains a groundwater budget for 1980. The aquifer is recharged by percolation from surface water irrigation, inflow from tributary valleys (which includes both groundwater underflow and surface water), precipitation, and seepage losses from the Snake River.

Estimates of recharge from percolation of surface water irrigation, tributary valley inflow, and precipitation totaled 4,800,000, 1,411,000, and 760,000 acre-feet, respectively (S. P. Garabedian, U.S. Geological Survey, written communication, 1983). Estimates of recharge from

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

WATER-RESOURCES INVESTIGATIONS 84-4001
PLATE 4



WATER-LEVEL HYDROGRAPHS AND LOCATIONS OF SELECTED WELLS, SNAKE RIVER PLAIN AQUIFER

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

WATER-RESOURCES INVESTIGATIONS 84-4001
PLATE 5

EXPLANATION

All numbers in acre-feet per year

Flow into the aquifer from adjacent area. Includes ground-water underflow and recharge from surface water

+ Recharge to the aquifer

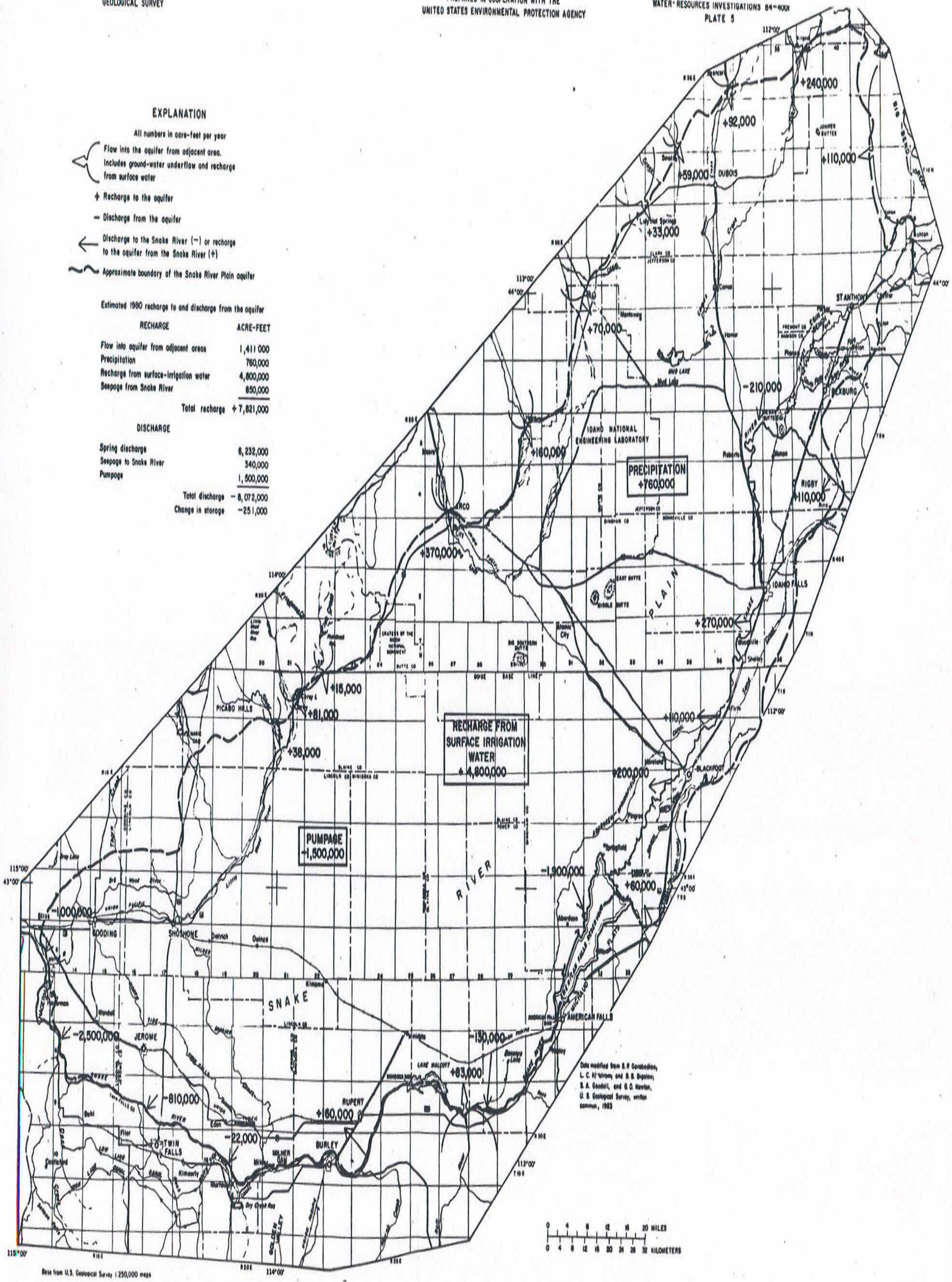
− Discharge from the aquifer

Discharge to the Snake River (−) or recharge to the aquifer from the Snake River (+)

Approximate boundary of the Snake River Plain aquifer

Estimated 1980 recharge to and discharge from the aquifer

RECHARGE	ACRE-FEET
Flow into aquifer from adjacent areas	1,411 000
Precipitation	760,000
Recharge from surface-irrigation water	4,800,000
Seepage from Snake River	850,000
Total recharge	+7,821,000
DISCHARGE	
Spring discharge	6,232,000
Seepage to Snake River	340,000
Pumpage	1,500,000
Total discharge	−8,072,000
Change in storage	−251,000



ESTIMATED 1980 RECHARGE TO AND DISCHARGE FROM THE SNAKE RIVER PLAIN AQUIFER seepage losses from the Snake River above Blackfoot totaled 850,000 acre feet (L. C. Kjelstrom, U.S. Geological Survey, written communication, 1983). Total recharge to the aquifer in 1980 was an estimated 7,820,000 acre-feet.

Discharge from the aquifer occurs as spring discharge, groundwater pumpage for irrigation, and seepage to the Snake River. Estimates of spring discharge and seepage to the Snake River totaled 6,232,000 and 340,000 acre-feet, respectively (L. C. Kjelstrom, U.S. Geological Survey, written communication, 1983). Groundwater pumpage for irrigation totaled 1,500,000 acre-feet (B. B. Bigelow, S. A. Goodell, and G. D. Newton, U.S. Geological Survey, written communication, 1983). Groundwater withdrawals for non-irrigation use are not included, because they, while unquantified, make up only a very small percentage of the whole.

An additional potential loss from the aquifer is groundwater evapotranspiration. However, depth to water in most parts of the aquifer is more than 50 feet and precludes any significant loss by this means.

Total discharge from the aquifer in 1980 was 8,072,000 acre-feet. The total recharge of 7,821,000 acre-feet subtracted from total discharge shows a reduction in storage of 251,000 acre-feet in 1980. Hydrographs on Plate 4, which indicate a general decline in water levels, also indicate a net loss in storage.

Spring Discharge

Springs issuing from the Snake Plain Aquifer occur singly, in clusters, and in continuous zones along the Snake River canyon between Milner and Bliss and along the Snake River near American Falls Reservoir between Blackfoot and Neeley. Continuous discharge data for Box Canyon and Blue Lakes Springs indicate that seasonal fluctuations in spring discharge coincides with the irrigation season. Hydrographs of discharge for Box Canyon and Blue Lakes Springs clearly show an increase in discharge shortly after the start of the irrigation season and a decrease in discharge shortly after the conclusion of the irrigation season. Only one measurement per year was available for the remaining springs. However, in 1980, several measurements were made at a number of springs and they show a similar increase in spring discharge corresponding with the irrigation season.

Hydrographs of annual discharge for the springs between Milner and Bliss and for springs near American Falls Reservoir for the period

1970-81 show a decrease in annual spring discharge starting in the mid-1970's, which is coincident with the declining water levels shown on Plate 4.

Groundwater/Surfacewater Relations

Plate 5 shows locations and quantities of groundwater discharge to the river and recharge to the aquifer from the river. Total exchanges of water between the aquifer and the Snake River in 1980 indicate a net recharge to the aquifer of 510,000 acre-feet.

Most of the water moving through the aquifer, as previously discussed, discharges to the Snake River as springs near American Falls Reservoir and between Milner and Bliss. However, the Snake River also loses to the groundwater system. Where the altitude of the water level is above the altitude of the river, groundwater discharges from the aquifer to the river. In areas where the altitude of the water level is below the altitude of the river, the aquifer is recharged by seepage from the river.

A continuing effort by state and federal agencies is being made to better define the complex interrelationships between the Snake River and the Snake Plain Aquifer. In some areas the relationship is relatively well known, in others the relationship is much more obscure. Lack of properly completed observation wells, unavoidable imprecision in gaging station values, inadequate knowledge of the subsurface geology and other factors make it difficult to precisely define reaches of gain to and loss from the aquifer.

The overall complexity of the Snake Plain Aquifer coupled with the uncertainty of its relationship to the Snake River in many areas makes it difficult to provide anything other than generalities in discussion of, for instance, the rate of contaminant movement from the point of contamination at land surface to its eventual discharge either in springs or by wells in areas of groundwater development.

Note: Although much of the above material was taken from USGS Water Resources Investigations Report 84-4001, which in turn was based on previous other publications listed in the Bibliography, much additional commentary was added by the Idaho Department of Water Resources. As a result, statements made and conclusions drawn are those of IDWR, and may or may not reflect the opinion of the USGS.

SOILS AND CLIMATE

Introduction

Soils and climate are important to the water quality of the Snake Plain Aquifer. Soils store much of the moisture from precipitation for plant growth thus reducing infiltration to groundwater. Soils are also media for the retention of nutrients and potential contaminants. Some potential contaminants are decomposed by the biological activity within the soil thus preventing their entry into the groundwater system. The kinds of parent materials from which soils form, interacting with climate, give rise to soil characteristics that are important to water movement and potential contaminant retention and decomposition. These characteristics are soil depth, slope, texture, drainage, permeability, pH, cation exchange capacity (CEC), and organic matter content. These characteristics are discussed in more detail later.

Climate

The climatic factors that are important are the amount of precipitation, temperature, and the period of precipitation. These factors affect the potential recharge by excess moisture, kinds of plants that grow, evapotranspiration and growing season.

The climate (Plate 6) is mainly semi-arid or Mediterranean that is borderline to Continental. A few small areas in the mountain foothills receive enough summer precipitation to be considered subhumid. The precipitation ranges from about 8 inches in the southwestern part of the area near Jerome and Hagerman to near 30 inches on the foothills north of St. Anthony and near Kilgore. Mountains on the west side of the plain create rain shadows that locally affect the distribution and amount of precipitation.

Precipitation comes as snow in late fall and winter and rain during the warmer months. The snow generally does not melt until early spring. The snowfall is reworked by wind forming drifts. The wind velocities and directions are fairly consistent from year to year as the snow drifts usually occur in about the same locations. This creates windswept areas with less effective moisture and snow drift areas with more effective moisture than the annual precipitation rate. On the basalt plains and lava beds, the snow accumulates in the cracks and fractures in the rock. Most

CLIMATIC ZONES; SNAKE PLAIN AQUIFER

EACH POLYGON REPRESENTS AN AREA OF SIMILAR ANNUAL PRECIPITATION (P) AND AVERAGE ANNUAL TEMPERATURE (T)

PLATE 6

SOURCE: 'CONSUMPTIVE IRRIGATION REQUIREMENTS FOR CROPS IN IDAHO' SUTTER & COREY, 1970 of the water from snow melt here goes directly into bedrock fractures where it can potentially move directly into the groundwater system.

The highest amount of rain comes in the spring. Rains that occur from mid-June through September usually wet the soil surfaces and contribute little to plant growth. During the summer there are isolated thunderstorms of various intensities.

Precipitation on the Snake Plain from near Hagerman to Idaho Falls ranges from about 8 to 12 inches. The soil is dry for more than one-half the time and only moist during winter and spring. The wetting front generally is less than 18 inches and the plants use all the moisture that the soil stores. In this area, irrigation is necessary for crop production. The potential for groundwater recharge from natural rainfall is low but excess irrigation water has a higher potential for recharge.

In the area from the Bennett Hills to near Arco and southwest of Big Southern Butte and in an area from about Ashton westerly to Dubois, the precipitation ranges from about 12 to as much as 20 inches. The wetting front in the soils may extend to a depth greater than 30 inches. Dryland agriculture is practical in parts of this area, however most farmed areas are irrigated. The potential for groundwater recharge from natural rainfall is low except in bedrock and lava areas. Excess irrigation water has a higher potential for groundwater recharge.

The average annual air temperature south of a line approximately between the east end of the Bennett Hills to Blackfoot ranges from about 45 to 50 degrees F. The frost free period ranges from about 110 days near Blackfoot to 150 days or more near Hagerman. As an example, the average annual temperature in the southern part of Minidoka County is 47.5 degrees F., the coldest month (January) has an average temperature of 24.5 degrees F. and the warmest month (July) has an average temperature of 71.5 degrees. North of this line the average annual air temperature is less than 45 degrees. The average annual air temperature at Idaho Falls is 44 degrees F., the coldest month (January) has an average temperature of 19.6 degrees F. and the warmest month (July) has an average air temperature of 68.9 degrees. The frost free period ranges for about 110 days at Blackfoot to less than 60 days near Kilgore. The major crop producing area in the northern Snake Plain, which is south of a line between Dubois and St. Anthony, has a frost free season of 70 to 110 days.

The air temperature affects the rate of transpiration of growing plants. The highest consumptive use of water is along the southern boundary of the area and the lowest use is in the most northern part near Dubois and Kilgore.

The length of the growing season affects the amount of time plants will be actively using soil moisture. The total annual use of moisture is lower in the northern part because of both lower consumptive use and a shorter period of use.

Soil Formation

Soils are a product of an interaction between the kinds of parent materials from which they were formed and the climate under which they were developed. The major parent materials for soils in the Snake Plain Aquifer area are:

1) Alluvium along the drainageways. Adjacent to the streams, the material has been deposited fairly recently. Terraces along the major drainages were mostly deposited by melt water during glacial periods.

2) Wind deposited silts (loess) and windblown sands. These deposits are found mainly to the east of major drainageways. Their sources are assumed to be from melt water deposits during glacial periods. Some minor deposits may have occurred in a more recent period. The source of the sand deposits is: (a) sandy outwash; (b) wind reworking of the sand from the loess and deposition closer to the source; (c) sandy shorelines of glacial lakes of which the present Mud Lake is a remnant. Study of the Landsat scenes indicate the sand dunes between St. Anthony and Dubois had as their sources the Big Lost River valley near Arco, shoreline deposits of Mud Lake and possibly some outwash on the west side of the Snake Plain near the junction of Henry's Fork and the Teton River.

3) Basalt Plains. Basalt plains with a mantle of less than 10 inches to 5 or more feet of wind deposited silt (loess), sand, and some alluvium are common in the Snake Plain. There were many different flows of lava and wide time spans between flows. The most recent is near the Craters of the Moon National Monument. Thickness of the mantle on the basalt plains depends on the time for accumulation and proximity to the source of the mantle material. The thickness of the mantle and roughness of the basalt flow control the soil

depth and slopes on the basalt plains. The older basalt plains generally have the thickest mantle of material and the more strongly developed soils.

4) <u>Old volcanoes.</u> These are prevalent in much of the area. There are two major kinds of volcanoes. One is the low relief shield volcanoes associated with the basalt flows. Soils formed on these are like those on most of the basalt plains. The taller prominent volcanoes, "Big Southern Butte" and "Twin Buttes" are mainly rhyolitic. Soil formed mainly in thin loess and alluvium over pyroclastic materials and old lava flows. The slopes are greater on the rhyolitic volcanoes so there is a higher amount of runoff. The highly developed soils are on the stable slopes. On some active slopes, the soils are weakly developed.

5) <u>Volcanic ash.</u> Some soils formed in material that is mostly volcanic ash. The largest area of these soils is near the Craters of the Moon. Nearly all loess contains some volcanic ash.

The kind and amount of native vegetation are related to the kind of soils and the climates. In general the vegetation in the drier, warmer part is drought tolerant grasses and sagebrush. In this area Wyoming big sagebrush and bluebunch, wheatgrass, Thurber needlegrasses, and Sandburg bluegrass are typical for the moderately deep and deep soils. Where the climate is cooler and precipitation is higher, the typical native vegetation is mountain big sagebrush, bitterbrush, Idaho fescue, and bluebunch wheat-grass. In areas of shallow soils, soils with dense subsoils and soils on windswept areas, the native vegetation is typically low sagebrushes, Sandburg bluegrass, and bluebunch wheatgrass. Some of the lava flows are nearly barren of vegetation except for bitterbrush and some grasses growing in small pockets and cracks. The youngest lava has the least amount of vegetation. On the north side of some of the volcanoes and on some foothills there are Douglas fir, aspen, lodgepole pine with an understory of brush and grasses. The amount and kind of vegetation affect the amount of moisture that moves through the soil into the aquifer.

The sandy warm areas have native vegetation that is mainly basin big sagebrush, Indian ricegrass, and needle-and-thread. The cooler sandy areas have mountain big sagebrush with needle-and-thread, Idaho fescue, and Indian ricegrass. The density of vegetation in sandy areas is quite variable. The amount of groundwater recharge is related to the amount of moisture that goes through the soil prior to and during the growing season and the density of cover.

Soil Thickness and Slope

The soil depth and thickness of the soil column are important to water storage and contaminant retention and decomposition. Soils in the Snake Plain Aquifer range from very shallow (less than 10 inches) on some basalt plains to very deep in the alluvial, loess and sandy deposits. On the basalt plains the shallow soils are on lava ridges. Moderately deep and some deep and very deep soils are in pockets and low areas. In most of the other deposits the soils are very deep, however in some alluvial areas soils have loose stratified gravel and sand at depths of 20 to 40 inches. In these areas contaminants can more readily move into the aquifer. This is especially true where these soils also have a water table within 60 inches of land surface sometime during the year. Areas of various sizes of these soils occur along the drainage system from Kilgore to near Heyburn. Some soils are shallow or moderately deep to a dense layer high in silica and calcium (duripan). These duripans develop at maximum depth of the wetting front. Soils with duripans transmit very little water into the aquifer.

Soil slope affects the amount of water entering the aquifer. Steeper slopes cause precipitation to run off of the steeper areas and concentrate in basins and along toeslopes. On steep slopes little water moves through the soil into underlying aquifers. However on north and east facing slopes where there are large snowdrifts, the amount of water used by plants is less. Excess moisture, therefore, moves into the underlying bedrock cracks or pyroclastic materials and may then enter the groundwater system.

Soil Texture

Soil texture affects the amount of water, nutrients, and potential contaminants that the soil can store. It also affects the rate that water can enter and move through the soil.

The surface texture of soils on the Snake Plain ranges from sands to clay loam. Most of the area has silt loam surface soil. Areas with sandy surfaces are mainly west of Jerome and south of Gooding, northeast of Mud Lake and northwest of St. Anthony and along the terrace east of Heyburn to near American Falls. Some alluvial areas and the old lake bed near Mud Lake have more clay in the soil surface. These soils are mainly clay loam. The amount of surface and subsurface rock fragments (gravel and cobbles) ranges from near 50 percent along some stream channels and on the basalt plains to none in the loess and wind deposited sands. The presences of rock fragments in the soil diminishes its storage capacity for water, nutrients and potential contaminants.

The texture of subsoils and substrata ranges from sands to heavy clay. Sandy textures are characteristic of soils developed from wind deposited sands and on the terraces along the Snake River and flood plains. Subsoils highest in clay are in the old Mud Lake bed and areas with soil material weathered from basalt. The clay content of these subsoils ranges from 35 to about 60%. In some small areas subsoils contain greater than 60% clay.

Moisture and Drainage

Most of the soils in the Snake Plain are well drained. Some areas of excessively drained soils are associated with the sand dunes northeast of Mud Lake and northwest of St. Anthony, sandy terraces along the Snake River and sandy areas west of Jerome. Some poorly drained soils with high water tables occur in small areas and include drainage ways and lake beds. These soils can be found in the Minidoka and Rupert area.and near the upper end of the American Falls Reservoir. In the plain, the water table ranges from near the surface to greater than several hundred feet. The basalt plains and loess areas generally have the deepest water tables.

The soil permeability (or rate that water moves through the soil) ranges from very rapid in sands and underlying gravels on terraces and flood plains to very slow for soil with high clay content or a duripan.

Soil pH and Cation Exchange Capacity

Soil pH and cation exchange capacity are important soil characteristics that affect the ability of soil to store nutrients and potential contaminants The soil pH ranges from strongly alkaline (pH 9.0) to medium acid (pH 5.6). The medium acid soils are of small acreage in the foothills where the native vegetation is forest. Soils in areas with 8 to 12 inches of precipitation have the highest pHs. These soils are generally high in lime (calcium carbonate), some contain sodium, and some have other salts. Generally these soils are leached free of lime to a depth of about 10 to 18 inches, however, some are calcareous to the surface. In areas of 12 to 20 inches of precipitation the soils are leached to depths of 18 to 30 inches and the surface and subsoils are neutral. The calcium carbonate is usually clay or fine silt size but it does not store nutrients as do clay particles. Some contaminants such as pesticides have rates of decomposition which are dependent on the soil pH. Some break down faster in an acidic medium, others decompose most rapidly in alkaline soils. The mobility or availability of trace elements such as iron, zinc, and boron is controlled by soil pH. Soil pH is also important in determining the availability of phosphorus, an important plant nutrient.

The cation exchange capacity (CEC) of soils refers to the soil's capacity to store or release positively charged ions (cations). The CEC is determined by soil properties such as organic matter content, clay content, and kind of clay. Organic matter has the highest CEC, ranging up to 200 meq/100 grams. Montmorillonite clay also has a high cation exchange capacity (>90 meq/100 grams) (Nettleton and Bracher, 1983). Montmorillonitic clays are dominant in some of the soils in lake beds and in soils weathered from basalt. Some other clays have high cation exchange capacities. Kaolinitic clays have the lowest CECs. However, soils in the Plain are low in kaolinitic clays.

Cation exchange capacity for silts and sands is very low. Nutrients and potential contaminants are more likely to move through the soil with the soil water, resulting in a greater chance for entry into the aquifer. Soils that are high in organic matter and montmorillonitic clay have the highest CEC. These soils will store nutrients and certain contaminants the longest. Some potential contaminants have limited active lives. The longer they are stored in the soil, the more likely they are to decompose and not enter the aquifer.

<u>Organic Matter</u>

Soils in the Snake Plain generally contain 1 to 3 percent organic matter but range from practically none on the sand dunes to nearly 100 percent for the organic soils near the upper end of the American Falls Reservoir. Organic matter content of the soil is important to the control of surface water pollution, air pollution and subsurface water pollution. Organic matter itself, however, can be a contaminant where its content is extremely high. Water flowing through saturated organic soils can become high in suspended organic soils.

Organic matter in the surface soil tends to promote soil aggregation and improve soil tilth. Soils that have little if any soil aggregates or have very small aggregates are subject to wind erosion. Soils with good aggregation do not erode by water as easily, thus runoff water carries less soil. The infiltration of water into soils is generally greater if there is